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# ANALYSIS OF THE VERIFICATION CRITERIA OF TESTING METHODS BY TENSION OF STEEL WIRES[**]

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***Abstract***

*One of the criteria in the laboratory practice for laboratory accreditation according to the requirements of the SRPS ISO/IEC 17025:2017 standard is the verification of methods. Verification - standard methods of testing the steel wires, has shown the verification and confirmation of methods in the specific laboratory test conditions, specified in the requirements of the SRPS ISO/IEC 17025:2017 standard. The requirements of the test method standards by verification have proved to the service user to have a confidence in the result obtained by its application. In the paper, the authors present the verification of the test method by tension of metal wires (ropes) at room temperature, Method B, according to the requirements of the SRPS EN ISO 6892-1:2020 standard.*

***Keywords:*** *analysis, criteria, method verification, tensile tests, steel wire*

## 1 INTRODUCTION

Accreditation of a laboratory is a means of confirming the technical competence of a laboratory that can meet the needs of users on the market. The laboratory gains its competence with accreditation to coordinate its products and services with the specific requirements and procedures of the international standard SRPS ISO/IEC 17025:2017. The accredited laboratory ensures its technical competence and quality of service provision for material testing by implementation the quality management system (QMS). To satisfy the user, the laboratory must establish, document, implement a quality management system under certain requirements of the standard [1]. Quality control can be divided into internal controls, where laboratories daily ensure the quality of work, and external controls, where many laboratories perform them, and their results are statically compared and evaluated to check the proficiency [2, 3].

One of the criteria for laboratory accreditation is the verification of standard methods. During method selection, the laboratory must use the appropriate methods and procedures for performing laboratory activities. The SRPS ISO/IEC 17025:2017 standard has requirements from the accredited laboratories

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that the standard methods must be checked and verified in application the standard methods in order to demonstrate their reliability. Checking of the standard method – verification proves that all the requirements of the standard of selected method are met. While the validation is a documented procedure that determines the suitability of measurement system for obtaining the useful analytical data [4].

During the rope operation in mining, there are changes in unfavorable conditions, because at high load there are broken wires and reduction in the cross-section S in the rope itself. To prevent a disaster, the rope must be constantly controlled. Control of the ropes must be constant during installation and operation. Steel rope is subjected to the stretching, compression, twisting and bending, so it requires the constant testing. Testing of the ropes for further use or rejection must be according to the instructions of equipment supplier and standards. The rope tested by the accredited laboratory receives a Rope Test Report where the results are given and by which method the tests were performed. Before testing the ropes, the user sends a Quality Certificate [3].

In this work, the standard method for testing the steel wires (ropes) is used by tensionning at room temperature, Method B, according to the requirements of the SRPS EN *ISO 6892-1:2020* standard. Tensile testing is one of the most important mechanical tests of materials, because it determines the most important parameters, such as: breaking (maximum) force Fm, tensile strength Rm, elasticity modulus, elongation (stretching), shrinkage, etc. The first experiments with wire tension to determine the tensile strength Rm were performed and described by Leonardo da Vinci [5].

Analysis of performance the verification of standard method for testing the steel wires by tension at room temperature, Method B, according to the requirements of the SRPS EN *ISO 6892-1:2020* standard is the input data for determining the dimensional measurement uncertainty.

The standard method is a method developed by the international organizations (SRPS ISO/IEC 17025, 2017).

The non-standard methods are methods developed in the laboratory and available in the scientific journals, as well as the modified standard methods [6-8].

Verification of the method shows that the method is reliable and accurate and that the results are consistent with the other laboratories using the same method, inter-laboratory comparative tests. The inter-laboratory comparative tests (eng. Proficiency testing schemes - PT schemes) are an external quality control of the method. The Pt schemes, developed with introduction the ISO 17025:1999 standard, became popular because they are mandatory in the accreditation process.

The criteria that determine the competence of a technical laboratory are also the appropriate management system and procedures, impartiality, confidentiality, responsibility and authorization, competent and experienced staff, appropriate calibrated equipment, valid test methods, inter-laboratory verification, control charts, measurement uncertainty and constant quality system verification (QMS) [9].

Integrated management system (ISM) as a process of quality management system integration, QMS in a modern business has become an obligation of every company in order to survive on the market. The results are better functioning, more organized processes and procedures, improved company performance and increased profits [10].

In the laboratories, where the method verification checks have been carried out, they are ready to perform the competent and reliable laboratory tests. Such laboratories are accredited by the Accreditation Body of Serbia (ATS) and are ready to work on the world market.

The organizer or providers of the PT schemes are obliged to prepare a report that includes the results achieved by the participating laboratories. The report also includes the methods used for testing and analyzing and the expected values for each measured quantity in each tested sample. The report should be precise and accurate without bias.

The organizer distributes the results of all participants in the PT scheme, as well as evaluates the reliability of the results of each participating laboratory. In the event that the test results are outside the range of expected and target values, the laboratories are forced to review the way of their work and determine the cause of deviation.

## 2 EXPERIMENTAL PART

### 2.1 Description of the method

This method is used to determine the tensile strength in tensioning the test samples of steel wires. The samples are loaded to breaking in a tensile strength testing device by tension, in accordance with the SRPS ISO 6892-1: 2020. The highest load, force Fm - breaking force (maximum force) are recorded and the tensile strength Rm of wire is calculated.

### 2.2 Description of the verification procedure

Evaluation of the laboratory work quality is carried out:

- By determining the individual competence of the employees in the laboratory on the basis of checking the acceptability of results of the test method over the critical interval CR $_{0.95}$.

The method for checking the acceptability of test results obtained under the repeatability conditions is based on comparison the range ($x_{max}$- $x_{min}$) of test results with the critical interval

CR $_{0.95}$ calculated from Table 1 for the corresponding n.

If the range does not exceed the critical interval, then the arithmetic mean of all n results is considered an acceptable measurement result.

**Table 1** *Factors for a critical interval f(n) [11]*

| n | f(n) | n | f(n) | n | f(n) | n | f(n) |
|---|---|---|---|---|---|---|---|
| **2** | 2.8 | 14 | 4.7 | 25 | 5.2 | 37 | 5.4 |
| **3** | 3.3 | 15 | 4.8 | 26 | 5.2 | 38 | 5.5 |
| **4** | 3.6 | 16 | 4.8 | 27 | 5.2 | 39 | 5.5 |
| **5** | 3.9 | 17 | 4.9 | 28 | 5.3 | 40 | 5.5 |
| **6** | 4.0 | 18 | 4.9 | 29 | 5.3 | 45 | 5.5 |
| **7** | 4.2 | 19 | 5.0 | 30 | 5.3 | 50 | 5.6 |
| **8** | 4.3 | 20 | 5.0 | 31 | 5.3 | 60 | 5.8 |
| **9** | 4.4 | 21 | 5.0 | 32 | 5.3 | 70 | 5.9 |
| **10** | 4.5 | 14 | 4.7 | 33 | 5.4 | 80 | 5.9 |
| **11** | 4.6 | 22 | 5.1 | 34 | 5.4 | 90 | 6.0 |
| **12** | 4.6 | 23 | 5.1 | 35 | 5.4 | 100 | 6.1 |
| **13** | 4.7 | 24 | 5.1 | 36 | 5.4 | | |

Verification of the method was performed by repeating the 8 measurements of tensile strength in tensioning the tested samples of metal wire, ropes.

The preparation procedure consists in the rope degreasing in its total length and washing well in gasoline, then unraveling into waists and further unraveling the waists into wires. Waists are marked with Roman numerals (most often from I to XVIII). Then the wires, each individually from the first coil, are well washed in gasoline or petroleum, manually straightened and numbered with numbers from I - 1, to I - n, where n is the total number of wires in the coil (easiest with a tape with a wire label).

The identical procedure of preparing and marking the wires is repeated with each subsequent waist.

After degreasing of wires, the next activity is cutting the wires to dimensions, i.e., length of samples necessary for testing the same on a tensile testing device, according to the requirements of the standard.

A part of each wire must remain, which is marked and kept in case of a need to repeat the mentioned test.

Record the maximum breaking force Fm, expressed in kN, tensile strength Rm in MPa ($N/mm^2$) and wire diameter d (r) mm.

Tensile strength during tensile testing must be expressed to the nearest 0.1 MPa ($N/mm^2$).

Test results are displayed by recalculating the measured values.

The obtained results are expressed by [12]:

- Average value of repeated tests $\bar{x}$;
- Standard deviation $S_r$;
- Repeatability limit r;
- Critical interval for n=8 tests at 95 % of probability level $CR_{0.95}$ (n).

## 3 RESULTS AND DISCUSSION

### 3.1 Factors affecting the accuracy of results

Since the tensile strength and breaking force are determined during the tensioning of test samples of steel wires, the factors that affect the accuracy of measurement are the error of micrometer, tensile testing device, as well as the error of operator.

After calculating the tensile strength and breaking force of steel wires, the obtained values are entered in Tables 1 and 2.

**Table 2** *The obtained values of tensile strength Rm*

| **Standard:** **SRPS ISO 6892-1: 2020** | **Method:** **Metallic materials - Tensile testing - Test method at room temperature, Method B** |
|---|---|
| Test No: | Test results Rm: in repeatability conditions |
| 1 | 1706 |
| 2 | 1708 |
| 3 | 1711 |
| 4 | 1710 |
| 5 | 1707 |
| 6 | 1691 |
| 7 | 1675 |
| 8 | 1689 |
| $\bar{x}$ | 1699.625 |
| n | 8 |
| *No. degrees of freedom* – ν=n-1 | 7 |
| ($x_{max}$- $x_{min}$) | 36 |
| *Standard deviation* $S_r$ | 13.07055 |
| f (n) | 4.3 |
| *Limit of repeatability* r =$1.96\sqrt{n}Sr$ | r = 1.96*2.8284*13.07055 = 72.4587 |
| *Limit of reproducibility* R =$1.96\sqrt{n}S_R$ | / |
| *Critical interval* $CR_{0.95}$ (n) = f(n) s | 4.3*13.07055 = 56.2 |
| Note: *Relation* ($x_{max}$- $x_{min}$) *and* $CR_{0.95}$ (n) | |
| Conclusion: | The calculated critical interval is greater than the difference between the maximum and minimum determination values ($x_{max}$ - $x_{min}$), which confirms the acceptability of results obtained by the applied test method |
| | 56.2>36 |

**Table 3** *The obtained values for breaking force Fm*

| **Standard:**<br>**SRPS ISO 6892-1: 2020** | **Method:**<br>**Metallic materials - Tensile testing - Test method at room temperature, Method B** |
|---|---|
| Test No.: | Test results Rm: in repeatability conditions |
| 1 | 5253 |
| 2 | 5259 |
| 3 | 5268 |
| 4 | 5265 |
| 5 | 5256 |
| 6 | 5259 |
| 7 | 5210 |
| 8 | 5253 |
| $\bar{x}$ | 5252.875 |
| n | 8 |
| *No. degrees of freedom –*<br>ν =n-1 | 7 |
| $(x_{max} - x_{min})$ | 58 |
| *Standard deviation*<br>$S_r$ | 18.122 |
| f (n) | (4.3) |
| *Limit of repeatability*<br>$r = 1.96\sqrt{n}Sr$ | 1.96*2.8284*18.122= 100.462 |
| *Limit of reproducibility*<br>$R = 1.96\sqrt{n}S_R$ | / |
| *Critical interval*<br>$CR_{0.95}(n) = f(n)\ s$ | 4.3*18.122 = 77.92 |
| Note:<br>*Relation*<br>$(x_{max} - x_{min})$ *and* $CR_{0.95}(n)$ | |
| Conclusion: | The calculated critical interval is greater than the difference between the maximum and minimum determination values $(x_{max} - x_{min})$, which confirms the acceptability of the results obtained by the applied test method.<br>77.92 > 58 |

## Analysis

The calculated critical interval is greater than the difference between the maximum and minimum determination values ($x_{max}$-$x_{min}$), which confirms the acceptability of results obtained in the test by the standard method: Metallic materials - Tensile testing Part 1: Test method at room temperature, Method B.

## CONCLUSION

This work provides a calculation of the standard verification method: verification: Metallic materials - Tensile testing - Test method at room temperature, Method B.

Verification of the method was carried out by repeating the 8 measurements by tensioning the steel wires, where the tensile strength Rm and the breaking force Fm were determined, when the tested samples were tensioned, steel wires (ropes).

The calculated critical interval is greater than the difference between the maximum and minimum determination values ($x_{max}$-$x_{min}$) for tensile strength Rm and breaking force Fm. This confirms the acceptability of the obtained results for the test standard method: Metallic materials - Tensile testing Part 1: Test method at room temperature, Method B.

The analysis of verification criteria for the steel wire tension testing method confirms the acceptability of the obtained results. This means that the standard method for testing the steel wires meets the requirements set by the standard. The analysis of results has shown that the test method is applicable for testing the steel wires (ropes) by tension.

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